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U.S. Department of Agriculture
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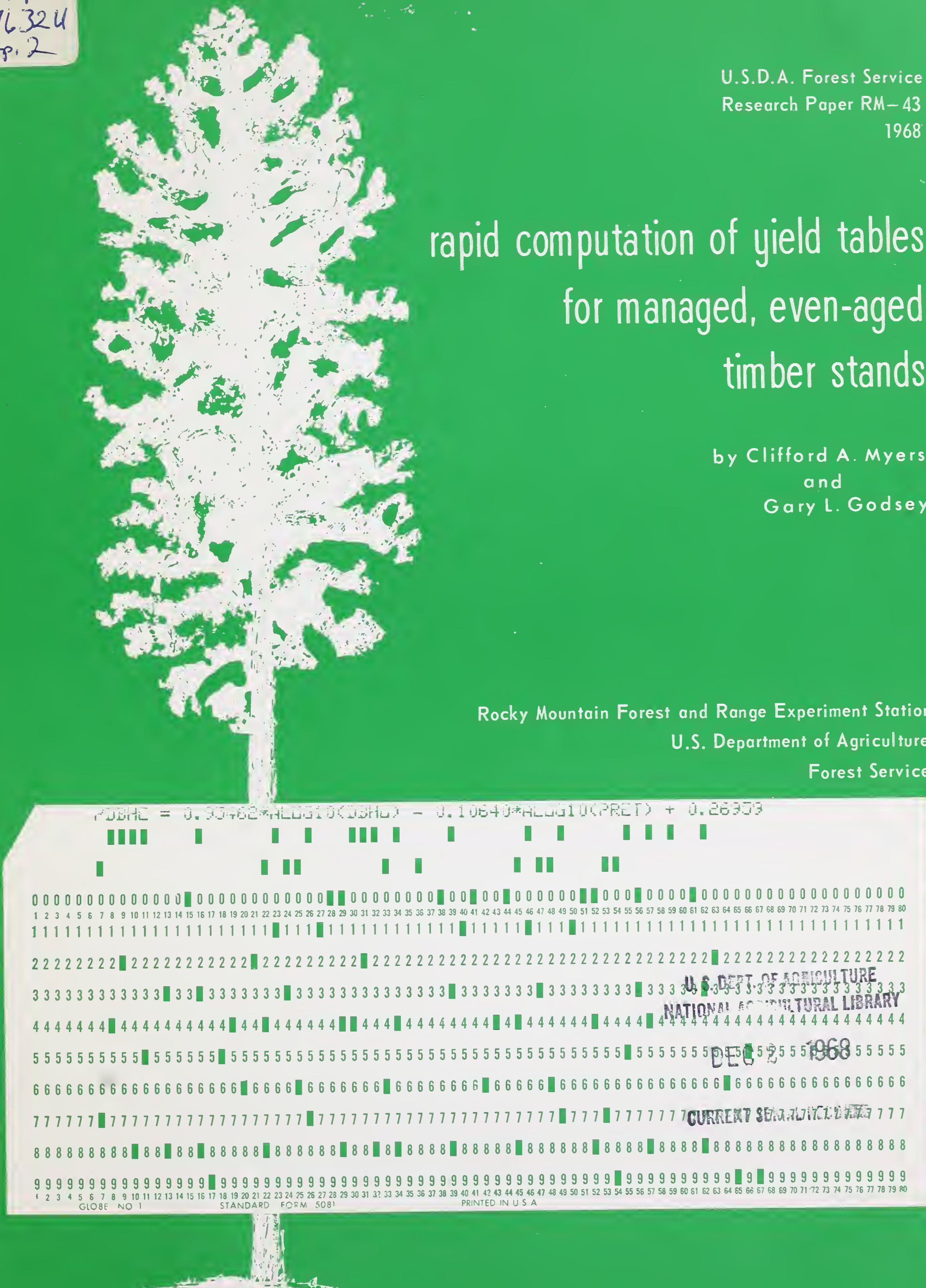

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Rapid Computation of Yield Tables for Managed, Even-Aged Timber Stands

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CONTENTS

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Clifford A. Myers and Gary L. Godsey

Introduction

Yield tables for managed stands are valuable guides for those who determine and for those who carry out timber management policies. Reported volumes are probable yields that result from specified combinations of such factors as frequency and intensity of thinning, site quality, and utilization standards. The volumes may be used to compute various money yields and costs (Myers 1968). There is, however, the disadvantage that a yield table reports probable yields for only one combination of stand characteristics and management decisions. Managers interested in comparing outcomes of several of the many alternatives possible do not find a yield table to be an effective basis for decisions. But a group of yield tables can be a useful tool for decisionmaking so long as the tables are not too costly in time and money.

Groups of yield tables can be obtained from measurements of trees on temporary plots and computations made on digital computers. Use of temporary instead of permanent plots avoids (1) long delays before yield tables become available, (2) possible loss of expensive installations, and (3) the possibility that changes in utilization and management practices will render the plots obsolete before much information can be obtained. Comparisons of data from temporary and permanent plots show that data from temporary plots are entirely adequate, and permit use of several approaches to yield table construction (Decourt 1965, Myers 1966, Vuokila 1965). Once several relationships between stand variables have been established, a manager can examine the probable outcomes of many possible variations in management. There is no need to delay decisions or to speculate on what may happen if a condition or procedure changes. Large numbers of tables, each based on a specified set of alternatives, can be computed and printed at a cost of a few cents each.

Procedure for computation of yield tables is presented here as two computer programs written in FORTRAN IV. Measurements needed and their use in mathematical expression of useful relationships are described in detail elsewhere (Myers 1966, 1967). Parts of this material are repeated in the section headed "Information Needed." The first program described, program YIELD (appendix 1), computes and prints a yield table for each specified combination of alternatives. Program THIN1 (appendix 2) calculates the increases in stand diameter caused by various intensities of initial thinning from below. These data are used to calculate a relationship used in program YIELD. Definitions of variables used in each program appear at the beginning of the program.

The two programs and test problems (appendices 1 and 2) use as examples relationships established for ponderosa pine (Pinus ponderosa Laws.) in the Black Hills of South Dakota and Wyoming. Both programs may be converted easily to apply to other standards of utilization and management, or to other tree species.

Information Needed

Computation of yield tables from temporary plot data requires at least seven items of information. Additional items may be necessary for some species. For example, mortality may be of importance in thinned stands, although it was not for the ponderosa pine used as the example. The seven basic items needed and procedures to obtain them are:

1. **Description of unthinned, young stands.**

Stands with the ages and densities expected at possible times of initial thinning are sampled. Age at initial thinning, number of trees per

acre, and average stand diameter are obtained for use as initial entries in yield tables. A variety of stands is sampled if age and density at time of initial thinning are variables of interest. Each plot also provides a cumulative stand table with numbers of trees in percent (Bruce and Schumacher 1950), for use in computation of postthinning diameters by program THIN1. Regressions of average diameter on density and age, and of percentage of trees on average diameter are established graphically or mathematically to obtain data on intermediate stand conditions not sampled.

2. **Diameter increase from growth.**

Sample plots in stands that represent a wide range of densities, average diameters, and site qualities are measured to obtain a means of estimating periodic diameter growth. Plot trees are bored at breast height to determine radial wood growth. Data are obtained to relate diameter inside bark to diameter outside bark and vice versa. Periodic wood and bark growths are subtracted from present diameters to get diameters at the beginning of the period. Present and past diameters are grouped in stand tables, with diameters of recently dead trees added to the past stand tables. Present and past stand tables are used to compute present and past basal areas per acre and average stand diameters.

Appropriate values from the past stands are used as independent variables to estimate average diameters at the end of the projection period. For example, future diameters of ponderosa pine can be estimated from initial diameter, initial basal area, and site index. The equation for a 10-year projection period appears in program YIELD as the long FORTRAN statement for DBHO.

The sample plots can also supply other needed values, such as heights and a stand volume equation.

3. **Diameter increase from thinning.**

Change in average stand diameter caused by intermediate cuttings subsequent to initial thinning can be estimated by trial marking of temporary plots. An average increase of 0.4 inch is used in the example of program YIELD. Rethinning to about the same density level (item 4) each time is assumed. Amount of increase was not correlated with tree size or stand density for the stands examined.

A method of estimating the increase in diameter caused by initial thinning is given in program THIN1.

4. **Stocking guide.**

A guide to the growing stock to be left after each intermediate cutting is prepared as a relationship between basal area and average stand diameter (table 1). Results of thinning studies and data from temporary plots are used to establish a graph of desirable basal area over diameter for local average site quality. "Best" stand density for each average diameter is based on such criteria as production in cubic feet and probable length of saw log rotations. Desired stand density varies with the objectives of management, so the series of "best" densities must be converted to a general relationship.

The curve of basal area on diameter can be considered as a guide curve from which a family of curves can be drawn or computed. Basal areas of table 1 increase with diameter until 10.0 inches is reached, and remain constant thereafter. Basal area is 80 square feet at 10.0 inches diameter, and the series is labeled level 80. Other possible series are identified by the basal area desired when average stand diameter is 10.0 inches or greater. Basal areas of any stocking level can be computed by multiplying the values for level 80 (table 1) by the ratio level/80. For example, basal areas for level 100 are each 100/80 times the corresponding basal areas of table 1.

Any desired form of the guide curve for the basal area-diameter relationship may be used. It will be necessary to modify appropriate statements of program YIELD for other bases than level 80.

5. **Dominant and codominant heights.**

Measurements on sample plots or values from good site index curves provide height-age-site index relationships (table 2). Average heights of dominant and codominant trees are usually more useful than other average heights. They are changed less than other averages when stands are cut according to most guides for intermediate cutting.

Table 1.--Basal areas after intermediate cutting in relation to average stand diameter
Growing stock level 80 for Black Hills ponderosa pine

Average stand d.b.h. after cutting (Inches)	Basal area per acre	Average stand d.b.h. after cutting (Inches)	Basal area per acre	Average stand d.b.h. after cutting (Inches)	Basal area per acre	Average stand d.b.h. after cutting (Inches)	Basal area per acre
	Sq. ft.		Sq. ft.		Sq. ft.		Sq. ft.
2.0	12.3	4.0	35.2	6.0	56.6	8.0	72.5
2.1	13.3	4.1	36.4	6.1	57.6	8.1	73.2
2.2	14.4	4.2	37.6	6.2	58.5	8.2	73.8
2.3	15.5	4.3	38.7	6.3	59.4	8.3	74.4
2.4	16.6	4.4	39.8	6.4	60.3	8.4	74.9
2.5	17.7	4.5	41.0	6.5	61.1	8.5	75.4
2.6	18.9	4.6	42.2	6.6	62.0	8.6	75.8
2.7	20.1	4.7	43.4	6.7	62.9	8.7	76.3
2.8	21.3	4.8	44.6	6.8	63.8	8.8	76.7
2.9	22.5	4.9	45.7	6.9	64.7	8.9	77.1
3.0	23.6	5.0	46.7	7.0	65.5	9.0	77.5
3.1	24.8	5.1	47.7	7.1	66.2	9.1	77.9
3.2	26.0	5.2	48.8	7.2	67.0	9.2	78.2
3.3	27.2	5.3	49.9	7.3	67.7	9.3	78.5
3.4	28.4	5.4	50.9	7.4	68.4	9.4	78.8
3.5	29.6	5.5	51.8	7.5	69.1	9.5	79.0
3.6	30.7	5.6	52.8	7.6	69.8	9.6	79.2
3.7	31.8	5.7	53.7	7.7	70.5	9.7	79.5
3.8	32.9	5.8	54.7	7.8	71.2	9.8	79.7
3.9	34.1	5.9	55.6	7.9	71.9	9.9	79.9
						10.0+	80.0

Table 2.--Average height of dominant and codominant trees at various ages, Black Hills ponderosa pine

Main stand age (Years)	Site index class			
	40	50	60	70
	- - - - - Feet - - - - -			
10	4.5	4.5	4.5	4.5
20	9	10	12	16
30	11	16	20	26
40	17	22	28	35
50	21	28	35	43
60	26	33	41	50
70	30	38	47	56
80	34	43	52	61
90	37	47	57	66
100	40	50	60	70
110	43	53	63	74
120	45	56	66	77
130	46	59	69	80
140	48	61	71	83
150	50	63	73	86
160	51	64	75	88
170	52	65	77	90
180	53	66	78	91

6. **Stand volume equation.**

Volumes measured on temporary growth plots and elsewhere provide the data needed to compute stand volume equations. Multiple regression methods are used to compute an equation for predicting total cubic feet per acre from other common stand measures. Independent variables most useful for ponderosa pine stands are basal area, average height of dominant and codominant trees, and average stand diameter. The equation appears at various places in program YIELD as statements for TOTO and TOTT.

7. **Volume conversion factors.**

Stand volumes in total cubic feet can be converted to volumes in cubic or board feet for any standard of utilization. Plot volumes in each measure and standard of interest are compared with corresponding total cubic volumes to obtain ratios or conversion factors (tables 3 and 4). Volume standards may be changed without change in the basic set of computations that produce yield tables.

Table 3.--Factors for conversion of stand volumes in total cubic feet to merchantable cubic feet per acre,[1] Black Hills ponderosa pine

Average stand diameter (Inches)	Ratio of merchantable to total volume	Average stand diameter (Inches)	Ratio of merchantable to total volume	Average stand diameter (Inches)	Ratio of merchantable to total volume
5.0	0.332	8.1	0.849	11.9	0.940
5.1	.355	8.2	.856	12.1	.941
5.2	.377	8.3	.862	12.4	.942
5.3	.400	8.4	.868	12.7	.943
5.4	.422	8.5	.872	12.9	.944
5.5	.444	8.6	.876	13.1	.945
5.6	.465	8.7	.880	13.3	.946
5.7	.487	8.8	.884	13.5	.947
5.8	.508	8.9	.888	13.7	.948
5.9	.530	9.0	.892	13.9	.949
6.0	.552	9.1	.896	14.2	.950
6.1	.575	9.2	.899	14.4	.951
6.2	.597	9.3	.902	14.7	.952
6.3	.618	9.4	.906	14.9	.953
6.4	.639	9.5	.910	15.2	.954
6.5	.659	9.6	.913	15.4	.955
6.6	.678	9.7	.916	15.8	.956
6.7	.694	9.8	.920	16.3	.957
6.8	.710	9.9	.923	16.8	.958
6.9	.725	10.0	.926	17.3	.959
7.0	.740	10.1	.928	17.8	.960
7.1	.753	10.2	.930	18.3	.961
7.2	.766	10.3	.931	18.8	.962
7.3	.778	10.4	.932	19.3	.963
7.4	.789	10.5	.933	19.8	.964
7.5	.799	10.7	.934	20.3	.965
7.6	.809	10.9	.935	20.9	.966
7.7	.818	11.1	.936	21.7	.967
7.8	.826	11.3	.937	22.5	.968
7.9	.834	11.5	.938	23.3	.969
8.0	.842	11.7	.939	23.9	.969

[1] To 4.0-inch top in trees 6.0 inches d.b.h. and larger.

Factor for an unlisted diameter equals factor for next smaller listed diameter. For example, factor for 15.6 inches is .955.

Table 4.--Factors for conversion of stand volumes in total cubic feet to board feet Scribner rule per acre,[1] Black Hills ponderosa pine

Average stand diameter (Inches)	Ratio of board feet to cubic feet	Average stand diameter (Inches)	Ratio of board feet to cubic feet	Average stand diameter (Inches)	Ratio of board feet to cubic feet	Average stand diameter (Inches)	Ratio of board feet to cubic feet
8.0	0.78	11.9	3.49	15.8	4.71	19.7	5.42
8.1	.85	12.0	3.56	15.9	4.73	19.8	5.44
8.2	.92	12.1	3.61	16.0	4.76	19.9	5.45
8.3	.99	12.2	3.65	16.1	4.78	20.0	5.46
8.4	1.06	12.3	3.69	16.2	4.81	20.1	5.47
8.5	1.13	12.4	3.73	16.3	4.83	20.2	5.48
8.6	1.20	12.5	3.77	16.4	4.86	20.3	5.50
8.7	1.27	12.6	3.80	16.5	4.88	20.4	5.51
8.8	1.34	12.7	3.84	16.6	4.90	20.5	5.52
8.9	1.41	12.8	3.88	16.7	4.92	20.6	5.53
9.0	1.48	12.9	3.91	16.8	4.94	20.7	5.54
9.1	1.55	13.0	3.95	16.9	4.96	20.8	5.56
9.2	1.62	13.1	3.98	17.0	4.98	20.9	5.57
9.3	1.68	13.2	4.02	17.1	5.00	21.0	5.58
9.4	1.75	13.3	4.05	17.2	5.02	21.1	5.59
9.5	1.82	13.4	4.08	17.3	5.04	21.2	5.60
9.6	1.89	13.5	4.11	17.4	5.06	21.3	5.61
9.7	1.96	13.6	4.14	17.5	5.08	21.4	5.62
9.8	2.03	13.7	4.17	17.6	5.10	21.5	5.63
9.9	2.10	13.8	4.20	17.7	5.12	21.6	5.64
10.0	2.17	13.9	4.23	17.8	5.13	21.7	5.65
10.1	2.24	14.0	4.25	17.9	5.15	21.8	5.66
10.2	2.31	14.1	4.28	18.0	5.17	21.9	5.67
10.3	2.38	14.2	4.31	18.1	5.19	22.0	5.68
10.4	2.45	14.3	4.34	18.2	5.21	22.1	5.69
10.5	2.52	14.4	4.37	18.3	5.22	22.2	5.70
10.6	2.59	14.5	4.39	18.4	5.24	22.3	5.71
10.7	2.65	14.6	4.42	18.5	5.26	22.4	5.72
10.8	2.72	14.7	4.44	18.6	5.27	22.5	5.73
10.9	2.79	14.8	4.47	18.7	5.29	22.6	5.74
11.0	2.86	14.9	4.49	18.8	5.30	22.7	5.75
11.1	2.93	15.0	4.52	18.9	5.32	22.8	5.76
11.2	3.00	15.1	4.54	19.0	5.33	22.9	5.77
11.3	3.07	15.2	4.56	19.1	5.35	23.0	5.78
11.4	3.14	15.3	4.58	19.2	5.36	23.1	5.79
11.5	3.21	15.4	4.61	19.3	5.37	23.2	5.80
11.6	3.28	15.5	4.64	19.4	5.39	23.3	5.81
11.7	3.35	15.6	4.66	19.5	5.40	23.4	5.82
11.8	3.42	15.7	4.68	19.6	5.41	23.5	5.83

[1] To 8-inch top in trees 10.0 inches d.b.h. and larger.

Description of Program YIELD

Operations performed by program YIELD are identified by the comment statements of the source program (appendix 1). Initial stand conditions and other values are read into computer memory in the order and format given in the tabulation of order and contents of the data deck. The number of yield tables computed and printed is determined by the values assigned NTSTS on card type 1 and MIX on card type 2. NTSTS is the number of sets of tables produced. MIX is the number of tables in a set or the number of stocking levels (DSTY) tested. Growing stock level for initial thinning may differ from that specified for rethinnings.

Diameter after initial thinning is estimated from diameter before thinning and an estimate of the percentage of trees to be retained. Computations are listed in FORTRAN statements 8 to 13. The first estimate of diameter, DBHE, is tested against the values in or computed from table 1 for the specified growing stock level. The estimate is modified as necessary until diameter and basal area of the yield table and of the growing stock level are equal. Derivation of the equation for PDBHE (logarithm of DBHE) is explained in the description of program THIN1.

Clearcutting at the oldest age of interest is assumed. The program can be modified to show the reservation of volume in a shelterwood or seed trees, if desired. Present assumptions apply to many species. For others, a change may be an unnecessary refinement where length of the period necessary for natural regeneration has not yet been established.

Replacement of several statements and data cards will modify the program for other species. Replacements needed are:

1. Tables 2 to 4, inclusive. It may be necessary to change the DIMENSION statement and statements that compute subscripts for table look-up.
2. Table 1, if desired. New statements for BREAK and DBHP, statement 9 and preceding, will be needed. Statements for DBHP are mathematical expressions of the first part of table 1, with diameter as the dependent variable. BREAK is the largest permissible basal area of the first equation and the lowest basal area of the second. Statements that contain the ratio of DLEV or THIN to 80.0 must be replaced if another system of labeling growing stock levels is used. This change was discussed in the description of table 1.
3. Statements for TOTO and TOTT, so cubic volumes per acre are correct for the species and tree volume equation selected.
4. Statement for PDBHE, based on program THIN1 and stand tables for the species.
5. Statement for DBHO, based on a growth study of the species of interest.
6. Table headings.

It may be necessary to account for the trees that die during the periods between thinnings. If so, the statement DENO=DENT must be replaced. It may be possible to relate mortality in numbers of trees to average stand diameter (Myers 1967).

Test Problem for YIELD

A problem is included (appendix 1) to provide additional description of the data deck and of the output. The test problem should be run to check accuracy of punching of the source deck and to test compatibility with local equipment.

Values used in the test problem were as follows:

NTSTS - 2	RINT - 10.0
JCYCL - 20	ROTA - 130.0
MIX - 5	SITE - 60.0
AGEO - 30.0	THIN - 120.0 and 80.0
DBHO - 4.5	TABL1(K) - Values in table 1
DENO - 1000.0	TABL2(K,L) - Values in table 2
DSTY - 70.0	TABL3(K) - Values in table 3
PRET - 27.0	TABL4(K) - Values in table 4

Values were the same for the two tests except for THIN. The test problem compares the effect on yields of initial thinning to growing stock levels 80 and 120, and of rethinning to each of several levels. One card or set of cards of each type, except type 1, was read for each test performed.

Output of the tests can be used in many ways to assist in decisionmaking. Yields and numbers of noncommercial cuts can be compared (table 5). Money yields and rates earned can be computed if necessary data on costs and stumpage values are available. Stand

Order and Contents of Data Deck for Program YIELD

Card type	No. of cards in type	Variable name	Columns	Format	Description of variable
1	1	NTSTS	1-4	I4	Number of tests in a batch. The number of sets of yield tables to be computed and printed for each combination of values on a card of type 3.
2	1	JCYCL	1-4	I4	Interval between intermediate cuts. A multiple of RINT.
		MIX	5-8	I4	Number of stocking levels or values of DLEV to be examined in one test.
3	1	AGEO	1-8	F8.3	Initial age to be shown in a yield table. Stand age when first thinning occurs.
		DBHO	9-16	F8.3	Average stand d.b.h. just prior to initial thinning at stand age AGEO.
		DENO	17-24	F8.3	Number of trees per acre just prior to initial thinning at age AGEO.
		DSTY	25-32	F8.3	Lowest growing stock level for intermediate cuts after initial thinning. Level will increase by 10 as many times as specified by MIX on card type 2.
		PRET	33-40	F8.3	Estimated percentage of trees to be retained after initial thinning at age AGEO.
		RINT	41-48	F8.3	Number of years for which the growth equation makes one projection of growth. Value is 10.0 for the equation for DBHO.
		ROTA	49-56	F8.3	Final age for which stand data are to be given in a yield table.
		SITE	57-64	F8.3	Site index for the species.
		THIN	65-72	F8.3	Growing stock level for initial thinning at age AGEO. May equal DLEV.
4	4	TABL1(K)	1-63	21F3.1	Table 1 of this publication or a similar table giving basal areas after thinning in relation to average stand d.b.h.
5	3	TABL2(K,L)	1-75	25F3.1	Table 2 of this publication or a similar table of tree heights by age and site index classes.
6	8	TABL3(K)	1-72	24F3.3	Table 3 of this publication or a similar table of factors for conversion of total cubic feet to merchantable cubic feet.
7	6	TABL4(K)	1-78	26F3.2	Table 4 of this publication or a similar table of factors for conversion of total cubic feet to board feet.

Table 5.--Comparison of alternatives included in the test problem[1]

Initial growing stock level	Subsequent stocking levels	Yields per acre		Number of precommercial thinnings
		Intermediate	Final	
		Cu. ft.	M. bd. ft.	
120	70	2450	13.8	1
	80	2470	14.9	1
	90	2360	15.9	1
	100	2290	17.0	1
	110	2270	17.7	1
80	70	2120	14.1	1
	80	1840	15.2	2
	90	1810	16.3	2
	100	1860	17.4	2
	110	1940	18.1	2

[1] Final cut in board feet at age 130. Intermediate cuts in cubic feet. Minimum commercial limit 300 cubic feet.

ages at culmination of mean annual increment, and rates earned assist in the determination of suitable rotations. Under the conditions specified for the test problem, rotations of about 130 years and initial thinnings that leave relatively large growing stocks appear worthy of further examination.

Description of Program THIN1

The FORTRAN statement for PDBHE that follows statement 8 of program YIELD computes the logarithm of estimated stand diameter after initial thinning. Independent variables are the logarithms of diameter before thinning and percentage of trees left after thinning. Equations for PDBHE are calculated from data produced by THIN1 (appendix 2). The program simulates several intensities of thinning from below in young stands with various average diameters.

Preliminary computations and operations performed by THIN1, described as though done manually with cards, are as follows:

1. Obtain cumulative percentage stand tables by 1-inch diameter classes, as described in item 1 of the section "Information Needed."
2. Convert each cumulative table to a stand table for 1,000 trees, and obtain the average diameter of each stand from average basal area. All trees in a class are assigned the diameter of the class midpoint.
3. Write the diameter of each tree of a stand on a card to create a deck of 1,000 cards that represents trees of a stand.
4. Shuffle the cards so they become arranged in random order.
5. Select a percentage of trees to be retained. The 1,000 cards will be separated into groups of equal size. One tree of each group will be left standing after thinning. Percentage retained equals 1/group size. Vary group size (no fractional cards) until the desired percentage is approximated as closely as possible. For example, separation of 1,000 cards into groups of 20 cards each gives a percentage retention of 1/20 or 5 percent.
6. Divide the deck of 1,000 randomly arranged cards into groups of the desired size, and tally the largest diameter in each group. This produces a postthinning stand table.
7. Compute average diameter from average basal area. Record initial diameter, postthinning diameter, and percentage of trees retained as one set of data from a simulated plot. Comparison of results of this procedure with values from thinned permanent plots gave differences of 0.1 inch or less.

The accompanying tabulation of order and contents of the data deck for THIN1 lists the variables for which numerical values are needed.

Order and Contents of the Data Deck for Program THIN1

Card type	No. of cards in type	Variable name	Columns	Format	Description of variable
1	1	TERM	1-4	F4.0	A whole number between 0 and 1023 in the pseudorandom number generator. Change in the value of TERM changes the starting point of the sequence of 1024 pseudorandom numbers.
		NDMS	5-8	I4	Number of stand tables to be tested.
		NGRP	9-12	I4	Number of group sizes to be tested. This is the number of values entered for GRPS(I) on card type 2.
2	1	GRPS(I)	1-50	10F5.0	Number of trees in each group, from which one will be chosen for the residual stand. Group sizes usually range from 2 to 20.
3	1	AVDM	1-5	F5.1	Average d.b.h. before thinning of one stand to be examined.
		NCLS	6-7	I2	Number of 1-inch d.b.h. classes in the stand that has average d.b.h. AVDM.
4	1	DBHC(I)	1-50	10F5.1	List of the class midpoints of the 1-inch d.b.h. classes in the stand described by card type 3. List in order of increasing size.
5	1	IFRQ(I)	1-40	10I4	Cumulative numbers of trees for the d.b.h. classes listed on card type 4. Order of listing corresponds to DBHC(I).

Additional description of the program is provided by the test problem in the following section and in appendix 2.

Arrays of diameters are arranged in random order in THIN1 through use of a pseudorandom number generator. An array of 1,000 numbers is produced by a generator of the form (Greenberger 1961):

$$X_{i+1} \equiv AX_i + C \pmod{2^P}$$

Terms A, C, and 2^P are given constant values in statement 7 of the source program. An initial value of X_i is read in as variable TERM so the series can be entered at numerous points.

Sets of data produced by THIN1, transformed as necessary, are used in multiple regression analysis to obtain an equation for PDBHE. It may be necessary to include more combinations of independent variables than the 20 shown in the test problem, and to extend their range of values. Enough combinations should be sampled to include desired values of the independent variables and to permit verification of transformations of the variables to linear relationships. Library programs for multiple regression are available at most computing centers.

Test Problem for THIN1

Values read in for the test problem of THIN1 (appendix 2) were as follows. Note that card types 3 to 5, inclusive, were included once for each stand table examined.

Decimal points identify numbers in F-format. Lengths of fields and formats of the numbers are given in the list of contents of the data deck. Diameter class midpoints are at the half-inch values because of the frequent use of full-inch classes for ponderosa pine.

Card type	Values					
1	21.0	4	5			
2	2.0	3.0	4.0	5.0	10.0	
3	2.5	5				
4	0.5	1.5	2.5	3.5	4.5	
5	165	433	749	983	1000	
3	3.0	5				
4	0.5	1.5	2.5	3.5	4.5	
5	86	265	563	877	1000	
3	3.4	6				
4	0.5	1.5	2.5	3.5	4.5	5.5
5	25	130	408	760	969	1000
3	4.0	6				
4	1.5	2.5	3.5	4.5	5.5	6.5
5	11	165	574	848	966	1000

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*Address request for copies to the originating office.

APPENDIX 1

Program YIELD and Output of Test Problem

Program YIELD

```
C
C OEFINITIONS OF VARIABLES IN PROGRAM YIELO
C
C AGEO = INITIAL AGE IN YIELO TABLE
C BASC = BASAL AREA CUT PER ACRE
C BASO = BASAL AREA PER ACRE BEFORE THINNING
C BAST = BASAL AREA PER ACRE AFTER THINNING
C BOFC = BOARO FEET CUT PER ACRE
C BOFO = BOARO FEET PER ACRE BEFORE THINNING
C BOFT = BOARO FEET PER ACRE AFTER THINNING
C CFMC = MERCHANTABLE CU.FT. CUT PER ACRE
C CFMO = MERCHANTABLE CU.FT. PER ACRE BEFORE THINNING
C CFMT = MERCHANTABLE CU.FT. PER ACRE AFTER THINNING
C OBHO = AVERAGE STANO O.B.H. BEFORE THINNING
C OBHT = AVERAGE STANO O.B.H. AFTER THINNING
C OENC = TREES CUT PER ACRE
C OENO = TREES PER ACRE BEFORE THINNING
C OENT = TREES PER ACRE AFTER THINNING
C OLEV = GROWING STOCK LEVEL FOR INTERMEOIATE CUTS
C OSTY = LOWEST VALUE OF OLEV USEO IN A TEST
C HTSO = TREE HEIGHT BEFORE THINNING
C HTST = TREE HEIGHT AFTER THINNING
C JCYCL = INTERVAL BETWEEN INTERMEOIATE CUTS
C MIX = NUMBER OF STOCKING LEVELS EXAMINEO PER TEST
C NTSTS = NUMBER OF TESTS PER BATCH,EACH WITH SEPARATE HEADER CAROS
C PRET = PERCENTAGE OF TREES RETAINEO AFTER INITIAL THINNING
C RINT = NUMBER OF YEARS FOR WHICH GROWTH PROJECTION IS MAOE
C ROTA = FINAL AGE IN YIELO TABLE
C SITE = SITE INOEX
C TABL1 = TABLE 1 OF THIS PUBLICATION OR SIMILAR OATA
C TABL2 = TABLE 2 OF THIS PUBLICATION OR SIMILAR OATA
C TABL3 = TABLE 3 OF THIS PUBLICATION OR SIMILAR OATA
C TABL4 = TABLE 4 OF THIS PUBLICATION OR SIMILAR DATA
C THIN = GROWING STOCK LEVEL FOR INITIAL THINNING
C TOTC = TOTAL CUBIC FEET CUT PER ACRE
C TOTO = TOTAL CUBIC FEET PER ACRE BEFORE THINNING
C TOTT = TOTAL CUBIC FEET PER ACRE AFTER THINNING
C
      DIMENSION TABL1(81),TABL2(4,18),TABL3(192),TABL4(156)
C
C     REAO NUMBER OF TESTS PER BATCH
C
      REAO (5,1) NTSTS
    1 FORMAT (I4)
      DO 31 I = 1,NTSTS
C
C ZERO VARIABLES ANO READ IN VALUES FOR A TEST
C
      BOFO = 0.0
      BOFT = 0.0
      CFMO = 0.0
      CFMT = 0.0
      OLEV = 0.0
      REAO (5,2) JCYCL,MIX
    2 FORMAT (2I4)
      REAO (5,3) AGEO,OBHO,OENO,OSTY,PRET,RINT,ROTA,SITE,THIN
    3 FORMAT (9F8.3)
      REAO (5,4) (TABL1(K),K=1,81)
    4 FORMAT (21F3.1)
      REAO (5,5) ((TABL2(K,L),K=1,4),L=1,18)
    5 FORMAT (25F3.1)
      REAO (5,6) (TABL3(K),K=1,192)
    6 FORMAT (24F3.3)
      REAO (5,7) (TABL4(K),K=1,156)
    7 FORMAT (26F3.2)
      AGEO1 = AGEO
      OBHO1 = OBHO
      OENO1 = OENO
C
C PROVIOE FOR SEVERAL GROWING STOCK LEVELS PER TEST
C
      OO 31 M = 1 , MIX
      A = M
      OLEV = (OSTY + (A*10.0)) - 10.0
      BASO = OENO * 0.0054542 * OBHO * OBHO
C
C OBTAIN HTSO FROM TABLE 2
C
      TEN = 10.0
      ISITE = (SITE/TEN-3.0) + 0.01
      IAGEO = (AGEO/TEN) + 0.01
      HTSO = TABL2(ISITE,IAGEO)
C
C COMPUTE TOTAL CUBIC FEET PER ACRE
C
      TOTO = ((0.4047 * BASO * HTSO) + (25.5970 * OBHO)) -191.6433
C
C COMPUTE MERCH. CU.FT. IF O.B.H. IS AT LEAST 5.0 INCHES
C
      IF (OBHO.LT.5.0) GO TO 8
      IOBHO = ((OBHO-5.0)*10.0) + 1.01
      XOBHO = TABL3(IOBHO)
      CFMO = TOTO * XOBHO
C
C COMPUTE BO. FT. IF O.B.H. IS AT LEAST 8.0 INCHES
C
      IF(OBHO.LT.8.0) GO TO 8
      JOBHO = ((OBHO-8.0)*10.0) + 1.01
      YOBHO = TABL4(JOBHO)
      BOFO = TOTO * YOBHO
C
C COMPUTE O.B.H. AFTER INITIAL THINNING
C
    8 OO 13 J = 1 , 100
      POBHE = (0.95462 * ALOG10(OBHO))-(0.10640 * ALOG10(PRET))+0.26959
      OBHE = 10.0 ** POBHE
      IOBHE = OBHE * 10.0 + 0.5
      OBHE = IOBHE
      OBHE = OBHE/TEN
      OENE = OENO * (PRET/100.0)
      BASE = (0.0054542 * OBHE * OBHE) * OENE
      BREAK = 49.9 * (THIN/80.0)
      IF(BASE.GT.BREAK) GO TO 9
      OBHP = (80.0/THIN)*(0.08733 * BASE) + 0.92247
      GO TO 10
    9 OBHP = (80.0/THIN) * (0.10938 * BASE) -0.17858
   10 IOBHP = OBHP * 10.0 + 0.5
      OBHP = IOBHP
      OBHP = OBHP/TEN
      IF(OBHP-OBHE) 11,14,12
   11 PRET = PRET + PRET * 0.02
      GO TO 13
   12 PRET = PRET - PRET * 0.02
   13 CONTINUE
   14 OBHT = OBHE
C
C COMPUTE BASAL AREA AFTER INITIAL THINNING
C
      JOBHT = ((OBHT - 2.0) * 10.0) + 1.01
      SQFT = TABL1(JOBHT)
      BAST = (THIN/80.0) * SQFT
C
C ENTER LOOP FOR REMAINING COMPUTATIONS ANO PRINTOUT
C
      OO 29 K = 1 , 100
      IF (AGEO.GE.ROTA)  GO TO 15
      OENT = BAST/(0.0054542 * OBHT * OBHT)
      HTST = HTSO
C
C COMPUTE TOTAL CUBIC FEET AFTER THINNING
C
      TOTT = ((0.4047 * BAST * HTST) + (25.5970 * OBHT)) -191.6433
C
C COMPUTE MERCH. CU. FT. IF O.B.H. IS AT LEAST 5.0 INCHES
C
      IF (OBHT.LT.5.0) GO TO 15
      IOBHT = ((OBHT - 5.0) * 10.0) + 1.01
      XOBHT = TABL3 (IOBHT)
      CFMT = TOTT * XOBHT
C
C COMPUTE BO. FT. IF O.B.H. IS AT LEAST 8.0 INCHES
C
      IF (OBHT.LT.8.0) GO TO 15
      JOBHT = ((OBHT - 8.0) * 10.0) + 1.01
      YOBHT = TABL4(JOBHT)
      BOFT = TOTT * YOBHT
C
C CHANGE MOOE ANO ROUNO OFF FOR PRINTING
C
   15 JAGEO = AGEO
      JSITE = SITE
      JOENO = OENO
      JHTSO = HTSO
      JTOTO = (TOTO/TEN) + 0.5
      JTOTO = JTOTO * 10
      JBASO = BASO + 0.5
      JCFMO = (CFMO/TEN) + 0.5
      JCFMO = JCFMO * 10
      JBOFO = (BOFO/100.0) + 0.5
      JBOFO = JBOFO * 100
      JOENT = OENT
      JHTST = HTST
      JTOTT = (TOTT/TEN) + 0.5
      JTOTT = JTOTT * 10
      JCFMT = (CFMT/TEN) + 0.5
      JCFMT = JCFMT * 10
      IF (JCFMT.GT.JCFMO) JCFMO = JCFMT
      JBOFT = (BOFT/100.0) + 0.5
      JBOFT = JBOFT * 100
      IF (JBOFT.GT.JBOFO) JBOFO = JBOFT
      JBAST = BAST + 0.5
      JOENC = JOENO - JOENT
      JBASC = JBASO - JBAST
      JTOTC = JTOTO - JTOTT
      JCFMC = JCFMO - JCFMT
      JBOFC = JBOFO - JBOFT
C
C WRITE HEAOINGS FOR YIELO TABLE
C
      IF (K.GE.2) GO TO 22
      WRITE (6,17) JSITE,JCYCL
   17 FORMAT (1H1/1H-,27X,81HYIELOS PER ACRE OF MANAGEO, EVEN-AGEO STANO
     1S OF PONOEROSA PINE IN THE BLACK HILLS/1H ,49X,10HSITE INOEX,I3,1H
     2,, I4, 19H-YEAR CUTTING CYCLE)
      WRITE (6,18)
   18 FORMAT (1HO,25X,38HENTIRE STANO BEFORE ANO AFTER THINNING,28X,26HP
```

```
     1ERIDDIC CUT AND MORTALITY)
      WRITE (6,19)
   19 FDRMAT (1H0,9X,5HSTAND,10X,5HBASAL,3X,7HAVERAGE,2X,7HAVERAGE,3X,5H
     1TDTAL,3X,9HMERCHANT-,3X,9HSAWTIMBER,9X,5HBASAL,4X,5HTDTAL,3X,9HMER
     2CHANT-,3X,9HSAWTIMBER)
      WRITE (6,20)
   20 FDRMAT (1H ,10X,3HAGE,4X,5HTREES,3X,4HAREA,4X,6HD.B.H.,3X,6HHEIGHT
     1,2X,6HVDLUME,2X,11HABLE VDLUME,4X,6HVDLUME,3X,5HTREES,3X,4HAREA,3X
     2,6HVDLUME,2X,11HABLE VDLUME,4X,6HVOLUME)
      WRITE (6,21)
   21 FORMAT (1H ,8X,7H(YEARS),3X,3HNO.,3X,6HSQ.FT.,4X,3HIN.,6X,3HFT.,4X
     1,6HCU.FT.,5X,6HCU.FT.,6X,6HBD.FT.,4X,3HND.,3X,6HSQ.FT.,2X,6HCU.FT.
     2,5X,6HCU.FT.,6X,6HBD.FT.)
   22 WRITE (6,23) JAGED,JDEND,JBASD,DBHD,JHTSO,JTOTD,JCFMD,JBDFO
   23 FDRMAT (1H0,9X,I4,4X,I5,2X,I4,5X,F5.1,5X,I3,4X,I5,6X,I5,6X,I6)
      IF (AGED.GE.RDTA) GD TO 30
      WRITE (6,24) JAGED,JDENT,JBAST,DBHT,JHTST,JTDTT,JCFMT,JBDFT,JDENC,
     1JBASC,JTDTC,JCFMC,JBDFC
   24 FDRMAT (1H ,9X,I4,4X,I5,2X,I4,5X,F5.1,5X,I3,4X,I5,6X,I5,6X,I6,4X,I
     15,3X,I3,5X,I4,6X,I4,8X,I5)
C
C COMPUTE VALUES FDR EACH PERIOD. THIN AS SPECIFIED
C
      IRINT = RINT
      IK = JCYCL/IRINT
      DO 26 L = 1,IK
      AGFO = AGED + RINT
      IF (AGED.GT.RDTA) GO TO 30
C
C COMPUTE NEW D.B.H. BEFDRE THINNING AND RDUND DFF TO 0.1 INCH
C
      DBHD = 1.0097 * DBHT + 0.0096 * SITE-(1.5766*ALDG10(BAST))+3.3021
      IDBHD = DBHO * 10.0 + 0.5
      OBHO = IDBHD
      DBHO = DBHD/TEN
      DEND = DENT
      BASD = DEND *(0.0054542 * OBHO * DBHD)
C
C OBTAIN HTSD FRDM TABLE 2
C
      ISITE = (SITE/TEN-3.0) + 0.01
      IAGED = (AGED/TEN) + 0.01
      HTSD = TABL2(ISITE,IAGED)
C
C COMPUTE TOTAL CUBIC FEET BEFDRE THINNING
C
      TDTD = (0.4047 * BASD * HTSD) + (25.5970 * DBHD)-191.6433
C
C COMPUTE MERCH CU.FT. IF D.B.H. IS AT LEAST 5.0 INCHES
C
      IF (DBHD.LT.5.0) GD TD 25
      IDBHD = ((DBHD-5.0)*10.0)+1.01
      XDBHD = TABL3(IDBHD)
      CFMD = TDTD * XDBHD
C
C COMPUTE BD.FT.IF OBH IS AT LEAST B.0 INCHES
C
      IF (DBHO.LT.8.0) GD TD 25
      JDBHO = ((DBHD-8.0)*10.0) + 1.01
      YDBHO = TABL4(JDBHO)
      BDFD = TDTD * YDBHO
   25 IF (L.EQ.IK) GD TD 27
C
C WRITE VALUES FDR PERIOD. IF THINNING NDT DUE
C
      KDENO = DEND
      KAGEO = AGED
      KHTSD = HTSD
      KBASD = BASD + 0.5
      KTDTD = (TDTD/TEN) + 0.5
      KTOTO = KTDTD * 10
      KCFMD = (CFMD/TEN) + 0.5
      KCFMD = KCFMD * 10
      KBDFD = (BDFD/100.0) + 0.5
      KBDFD = KBDFD * 100
      WRITE (6,23) KAGED,KDENO,KBASD,DBHD,KHTSD,KTDTD,KCFMD,KBDFD
      DBHT = DBHD
      BAST = BASD
   26 CDNTINUE
C
C     INCREASE D.B.H. BY THINNING AND CDMPUTE PDST-THINNING VALUES
C
   27 DBHT = DBHD + 0.4
      IF (DBHT.GE.10.0) GD TD 28
      JDBHT = ((DBHT-2.0)*10.0) +1.01
      SQFT = TABL1(JDBHT)
      BAST = (DLEV/80.0)*SQFT
      GD TD 29
   28 BAST = DLEV
   29 CDNTINUE
C
C PREPARE FDR NEXT TABLE DF THE TEST
C
   30 AGEO = AGEO1
      BDFD = 0.0
      BDFT = 0.0
      CFMD = 0.0
      CFMT = 0.0
      DBHD = DBHO1
      DENO = DENO1
   31 CDNTINUE
      CALL EXIT
      END
```

YIELD Output

YIELDS PER ACRE DF MANAGED, EVEN-AGEO STANDS DF PDNDERDSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

	ENTIRE STAND BEFDRE AND AFTER THINNING							PERIDDIC CUT AND MDRTALITY				
STAND AGE (YEARS)	TREES ND.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TDTAL VDLUME CU.FT.	MERCHANT-ABLE VDLUME CU.FT.	SAWTIMBER VDLUME BD.FT.	TREES ND.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	200	0					
30	496	73	5.2	20	530	200	0	504	37	290	0	0
40	496	104	6.2	28	1150	680	0					
50	496	133	7.0	35	1870	1380	0					
50	200	60	7.4	35	850	670	0	296	73	1020	710	0
60	200	79	8.5	41	1340	1170	1500					
70	200	99	9.5	47	1930	1750	3500					
70	130	70	9.9	47	1390	1280	2900	70	29	540	470	600
80	130	86	11.0	52	1910	1780	5500					
90	130	101	11.9	57	2440	2300	8500					
90	84	70	12.3	57	1740	1640	6400	46	31	700	660	2100
100	84	83	13.4	60	2170	2050	8800					
110	84	96	14.4	63	2620	2490	11500					
110	58	70	14.8	63	1970	1880	8800	26	26	650	610	2700
120	58	81	15.9	66	2370	2270	11200					
130	58	91	16.9	69	2790	2670	13800					

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC CUT AND MORTALITY				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	200	0					
30	496	73	5.2	20	530	200	0	504	37	290	0	0
40	496	104	6.2	28	1150	680	0					
50	496	133	7.0	35	1870	1380	0					
50	229	68	7.4	35	970	760	0	267	65	900	620	0
60	229	90	8.5	41	1520	1330	1700					
70	229	110	9.4	47	2150	1950	3800					
70	152	80	9.8	47	1580	1450	3200	77	30	570	500	600
80	152	97	10.8	52	2120	1980	5800					
90	152	114	11.7	57	2730	2560	9100					
90	100	80	12.1	57	1960	1850	7100	52	34	770	710	2000
100	100	94	13.1	60	2420	2290	9600					
110	100	107	14.0	63	2900	2750	12300					
110	70	80	14.4	63	2220	2110	9700	30	27	680	640	2600
120	70	91	15.4	66	2650	2530	12200					
130	70	103	16.3	69	3090	2960	14900					

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC CUT AND MORTALITY				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	200	0					
30	496	73	5.2	20	530	200	0	504	37	290	0	0
40	496	104	6.2	28	1150	680	0					
50	496	133	7.0	35	1870	1380	0					
50	257	77	7.4	35	1090	860	0	239	56	780	520	0
60	257	99	8.4	41	1670	1450	1800					
70	257	119	9.2	47	2310	2070	3700					
70	177	89	9.6	47	1750	1600	3300	80	30	560	470	400
80	177	107	10.5	52	2320	2160	5800					
90	177	123	11.3	57	2950	2760	9000					
90	120	90	11.7	57	2180	2050	7300	57	33	770	710	1700
100	120	104	12.6	60	2670	2510	10100					
110	120	118	13.4	63	3160	2990	12900					
110	86	90	13.8	63	2460	2330	10300	34	28	700	660	2600
120	86	102	14.7	66	2910	2770	12900					
130	86	115	15.6	69	3420	3270	15900					

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC CUT AND MORTALITY				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	200	0					
30	496	73	5.2	20	530	200	0	504	37	290	0	0
40	496	104	6.2	28	1150	680	0					
50	496	133	7.0	35	1870	1380	0					
50	286	86	7.4	35	1210	950	0	210	47	660	430	0
60	286	108	8.3	41	1810	1560	1800					
70	286	129	9.1	47	2500	2240	3900					
70	200	99	9.5	47	1930	1760	3500	86	30	570	480	400
80	200	116	10.3	52	2510	2340	6000					
90	200	132	11.0	57	3140	2940	9000					
90	141	100	11.4	57	2410	2260	7600	59	32	730	680	1400
100	141	115	12.2	60	2900	2730	10600					
110	141	130	13.0	63	3460	3260	13700					
110	102	100	13.4	63	2700	2560	11000	39	30	760	700	2700
120	102	114	14.3	66	3220	3060	14000					
130	102	127	15.1	69	3740	3560	17000					

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC CUT AND MORTALITY				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	200	0					
30	496	73	5.2	20	530	200	0	504	37	290	0	0
40	496	104	6.2	28	1150	680	0					
50	496	133	7.0	35	1870	1380	0					
50	314	94	7.4	35	1330	1050	0	182	39	540	330	0
60	314	115	8.2	41	1930	1660	1800					
70	314	136	8.9	47	2620	2330	3700					
70	228	108	9.3	47	2100	1890	3500	86	28	520	440	200
80	228	127	10.1	52	2750	2550	6200					
90	228	146	10.8	57	3440	3220	9400					
90	160	110	11.2	57	2630	2460	7900	68	36	810	760	1500
100	160	126	12.0	60	3180	2990	11300					
110	160	141	12.7	63	3740	3530	14400					
110	117	110	13.1	63	2950	2790	11700	43	31	790	740	2700
120	117	124	13.9	66	3470	3300	14700					
130	117	137	14.6	69	4000	3800	17700					

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC CUT AND MORTALITY				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	150	0					
30	320	51	5.4	20	360	150	0	680	59	460	0	0
40	320	76	6.6	28	840	570	0					
50	320	101	7.6	35	1430	1160	700					
50	181	63	8.0	35	910	770	700	139	38	520	390	0
60	181	82	9.1	41	1400	1260	2200					
70	181	99	10.0	47	1950	1810	4200					
70	118	70	10.4	47	1410	1310	3400	63	29	540	500	800
80	118	86	11.5	52	1900	1790	6100					
90	118	100	12.4	57	2420	2280	9000					
90	78	70	12.8	57	1750	1650	6800	40	30	670	630	2200
100	78	83	13.9	60	2170	2060	9200					
110	78	95	14.9	63	2610	2490	11700					
110	54	70	15.3	63	1980	1890	9100	24	25	630	600	2600
120	54	80	16.4	66	2380	2270	11500					
130	54	91	17.4	69	2780	2670	14100					

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC CUT AND MORTALITY				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	150	0					
30	320	51	5.4	20	360	150	0	680	59	460	0	0
40	320	76	6.6	28	840	570	0					
50	320	101	7.6	35	1430	1160	800					
50	207	73	8.0	35	1040	880	800	113	28	390	280	0
60	207	92	9.0	41	1560	1390	2300					
70	207	111	9.9	47	2170	2010	4600					
70	138	80	10.3	47	1590	1480	3800	69	31	580	530	800
80	138	96	11.3	52	2120	1990	6500					
90	138	112	12.2	57	2710	2550	9900					
90	92	80	12.6	57	1980	1860	7500	46	32	730	690	2400
100	92	93	13.6	60	2420	2290	10000					
110	92	106	14.5	63	2880	2740	12600					
110	66	80	14.9	63	2230	2120	10000	26	26	650	620	2600
120	66	91	15.9	66	2650	2530	12500					
130	66	102	16.8	69	3080	2950	15200					

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC CUT AND MORTALITY				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	150	0					
30	320	51	5.4	20	360	150	0	680	59	460	0	0
40	320	76	6.6	28	840	570	0					
50	320	101	7.6	35	1430	1160	900					
50	233	82	8.0	35	1170	980	900	87	19	260	180	0
60	233	101	8.9	41	1710	1520	2400					
70	233	120	9.7	47	2340	2140	4600					
70	161	90	10.1	47	1780	1650	4000	72	30	560	490	600
80	161	107	11.0	52	2340	2180	6700					
90	161	123	11.8	57	2940	2760	10100					
90	110	90	12.2	57	2200	2070	8000	51	33	740	690	2100
100	110	104	13.1	60	2660	2520	10600					
110	110	117	13.9	63	3140	2980	13300					
110	80	90	14.3	63	2470	2350	10700	30	27	670	630	2600
120	80	102	15.2	66	2910	2780	13300					
130	80	114	16.1	69	3410	3260	16300					

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC CUT AND MORTALITY				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	150	0					
30	320	51	5.4	20	360	150	0	680	59	460	0	0
40	320	76	6.6	28	840	570	0					
50	320	101	7.6	35	1430	1160	1000					
50	259	91	8.0	35	1300	1090	1000	61	10	130	70	0
60	259	112	8.9	41	1900	1680	2700					
70	259	130	9.6	47	2540	2320	4800					
70	183	100	10.0	47	1970	1820	4300	76	30	570	500	500
80	183	117	10.8	52	2540	2370	6900					
90	183	132	11.5	57	3150	2960	10100					
90	129	100	11.9	57	2420	2270	8400	54	32	730	690	1700
100	129	114	12.7	60	2900	2730	11100					
110	129	129	13.5	63	3440	3250	14100					
110	94	100	13.9	63	2710	2580	11500	35	29	730	670	2600
120	94	113	14.8	66	3220	3060	14400					
130	94	126	15.6	69	3720	3560	17400					

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE IN THE BLACK HILLS
SITE INDEX 60, 20-YEAR CUTTING CYCLE

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC CUT AND MORTALITY				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	20	820	150	0					
30	320	51	5.4	20	360	150	0	680	59	460	0	0
40	320	76	6.6	28	840	570	0					
50	320	101	7.6	35	1430	1200	1100					
50	285	100	8.0	35	1430	1200	1100	35	1	0	0	0
60	285	121	8.8	41	2040	1800	2700					
70	285	141	9.5	47	2730	2480	5000					
70	205	110	9.9	47	2150	1990	4500	80	31	580	490	500
80	205	128	10.7	52	2780	2600	7400					
90	205	146	11.4	57	3460	3240	10900					
90	144	110	11.8	57	2650	2490	9100	61	36	810	750	1800
100	144	125	12.6	60	3180	2990	12100					
110	144	140	13.3	63	3710	3510	15000					
110	107	110	13.7	63	2960	2810	12400	37	30	750	700	2600
120	107	123	14.5	66	3470	3300	15200					
130	107	135	15.2	69	3980	3800	18100					

APPENDIX 2

Program THIN1 and Output of Test Problem

Program THIN1

```
C
C     DEFINITIONS OF VARIABLES
C     ADBD = AVERAGE DIAMETER BEFORE THINNING
C     ADBT = AVERAGE DIAMETER AFTER THINNING
C     AVBA = AVERAGE BASAL AREA OF RESERVED TREES
C     AVDM = AVERAGE STAND DBH BEFORE THINNING
C     BAST = BASAL AREA OF RESERVED TREES
C     DBHC = DIAMETER CLASS OF A STAND TABLE
C     DIAM = INDIVIDUAL DIAMETERS FROM DBHC AND IFRQ
C     IFRQ = CUMULATIVE NUMBER OF TREES BY DBH CLASSES
C     IRND = RANDOM NUMBERS FROM 1 TO 1000
C     NCLS = NUMBER OF ONE-INCH DBH CLASSES IN STAND TABLE
C     NDMS = NUMBER OF AVERAGE STAND DIAMETERS TESTED
C     PRET = PERCENTAGE OF TREES LEFT AFTER THINNING
C     RSRV = DIAMETER OF A RESERVED TREE
C     SDSQ = SUM OF SQUARED DIAMETERS
C     TERM = TERM IN PSEUDORANDOM NUMBER GENERATOR
C     TREE = INDIVIDUAL DIAMETERS ARRANGED AT RANDOM
C     GRPS = GROUP SIZE FOR THINNING INTENSITY
C     NGRP = NUMBER OF GROUP SIZES TESTED
C     NDGP = NUMBER OF GROUPS,EACH OF SIZE GRPS
C
      DIMENSION DBHC(10),IFRQ(10),DIAM(1000),TREE(1000),IRND(1000),
     1RSRV(1000),PRET(10),ADBD(10),ADBT(10,10),GRPS(10)
C
C     INITIALIZE AND READ VARIABLES USED FOR ALL STAND TABLES
C
      DO 1 I=1,10
      ADBD(I) = 0.0
      GRPS(I) = 0.0
    1 PRET(I) = 0.0
      DO 2 I=1,10
      DO 2 J=1,10
    2 ADBT(I,J) = 0.0
      DO 3 I=1,1000
    3 IRND(I) = 0
      READ (5,4) TERM,NDMS,NGRP
    4 FORMAT (F4.0,2I4)
      READ (5,5) (GRPS(I),I=1,NGRP)
    5 FORMAT (10F5.0)
C
C     COMPUTE PERCENTAGE OF TREES RETAINED FOR EACH GROUP SIZE
C
      DO 6 I=1,NGRP
    6 PRET(I) = 100.0/GRPS(I)
C
C     GENERATE 1000 PSEUDORANDOM NUMBERS
C
      DO 8 I=1,1000
    7 NDIV = (17.0 * TERM + 3.0)/1024.0
      NTERM = TERM
      NTERM = (17 * NTERM + 3)- 1024 * NDIV
      TERM = NTERM
      IF (NTERM .LE. 0) GO TO 7
      IF (NTERM .GT. 1000) GO TO 7
    8 IRND(I) = NTERM
C
C     DO COMPUTATIONS FOR EACH STAND TABLE
C
      DO 21 N=1,NDMS
C
C     INITIALIZE AND READ FOR EACH STAND TABLE
C
      DO 9 I=1,10
      DBHC(I) = 0.0
    9 IFRQ(I) = 0
      DO 10 I=1,1000
      DIAM(I) = 0.0
      RSRV(I) = 0.0
   10 TREE(I) = 0.0
      READ (5,11) AVDM,NCLS
   11 FORMAT (F5.1,I2)
      ADBD(N) = AVDM
      READ (5,12) (DBHC(I),I=1,NCLS)
   12 FORMAT (10F5.1)
      READ (5,13) (IFRQ(I),I=1,NCLS)
   13 FORMAT (10I4)
C
C     EXPAND STAND TABLE TO 1000 INDIVIDUAL DIAMETERS
C
      IX = 1
      DO 15 K=1,NCLS
      JX = IFRQ(K)
      DO 14 L=IX,JX
   14 DIAM(L) = DBHC(K)
   15 IX = 1 + JX
C
C     ARRANGE INDIVIDUAL DIAMETERS AT RANDOM
C
      DO 16 IK=1,1000
      NBR = IRND(IK)
      DMTR = DIAM (IK)
   16 TREE(NBR) = DMTR
C
C     CREATE GROUPS OF SPECIFIED SIZES.
C     RECORD LARGEST DBH IN EACH GROUP
C
      DO 21 M=1,NGRP
      BAST = 0.0
      AVBA = 0.0
      SDSQ = 0.0
      NDGP = 1000.0/GRPS(M)
      ANDGP = NDGP
      LX = 1
      IGRP = GRPS(M)
      MX = IGRP
      DO 19 IJ=1,NDGP
      DO 17 IL=1,NCLS
      JK = NCLS - IL + 1
      DO 17 NK=LX,MX
      IF (TREE(NK) .EQ. DBHC(JK)) GO TO 18
   17 CONTINUE
   18 RSRV(IJ) = DBHC(JK)
      LX = MX + 1
   19 MX = MX + IGRP
C
C     COMPUTE POST-THINNING STAND DIAMETER FROM BASAL AREA
C
      DO 20 KL=1,NDGP
   20 SDSQ = SDSQ + RSRV(KL) * RSRV(KL)
      BAST = 0.0054542 * SDSQ
      AVBA = BAST/ANDGP
      DMSQ = AVBA/0.0054542
      ADBT(N,M) = SQRT(DMSQ)
   21 CONTINUE
      WRITE (6,22)
   22 FORMAT (1H1,////,43X,48HAVERAGE STAND DIAMETER AFTER THINNING FROM
     1 BELOW)
      WRITE (6,23)
   23 FORMAT (1H ,54X,26HBLACK HILLS PONDEROSA PINE)
      WRITE (6,24)
   24 FORMAT (1H0,13X,8HDIAMETER/1H ,14X,6HBEFORE/1H .13X,8HTHINNING,32X
     1,25HPERCENT OF TREES RETAINED)
      WRITE (6,25) (PRET(I),I=1,NGRP)
   25 FORMAT (1H ,13X,8H(INCHES), 6X,F4.1,9(7X,F4.1))
      DO 27 MN=1,NDMS
      WRITE (6,26) ADBD(MN),(ADBT(MN,MK),MK=1,NGRP)
   26 FORMAT ( 1H0, 16X, F4.1, 7X, F4.1, 9(7X,F4.1))
   27 CONTINUE
      CALL EXIT
      END
```

THIN1 Output

AVERAGE STAND DIAMETER AFTER THINNING FROM BELOW
BLACK HILLS PONDEROSA PINE

DIAMETER BEFORE THINNING (INCHES)	PERCENT OF TREES RETAINED 50.0	33.3	25.0	20.0	10.0
2.5	2.9	3.1	3.3	3.4	3.6
3.0	3.4	3.7	3.9	4.0	4.3
3.4	3.9	4.2	4.3	4.4	4.7
4.0	4.6	4.9	5.1	5.3	5.7

Agriculture — CSU, Ft. Collins

Myers, Clifford A., and Godsey, Gary L.
1968. Rapid computation of yield tables for managed, even-aged timber stands. U.S.D.A. Forest Service Research Paper RM-43, 16 pp. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

Sets of yield tables that show probable results of various management alternatives can be valuable tools for decisionmaking, especially when they can be made available quickly and at relatively low cost. Such tables can be obtained with data from temporary plots and the computer programs presented.

Key words: Yields, managed stands, timber management

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Key words: Yields, managed stands, timber management